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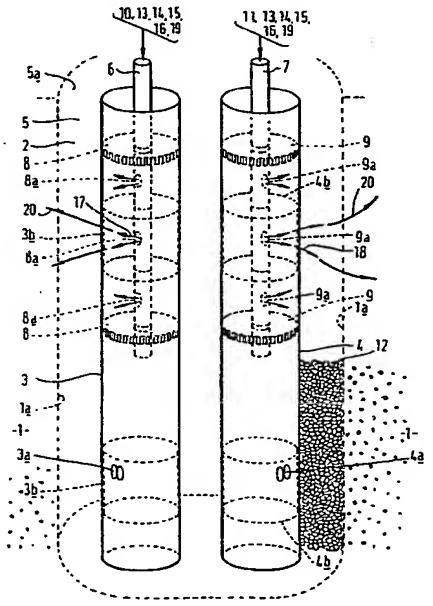
(54) **A soil treatment process**

(57) A process for the improvement of the load-bearing properties of soil containing loose stones comprises injecting liquids of differing compositions through two injection pipes 6 and 7 into a bore hole previously filled with a solidified foam sealing material. The injection liquids are discharged into the foam sealing material through valved outlets 3a and 4a of tubular members 3 and 4 within which the injection pipes 6 and 7 and slidably received; the injection liquids mixing together and reacting within the bore hole to penetrate the foam sealing material and enter the soil surrounding the bore hole.



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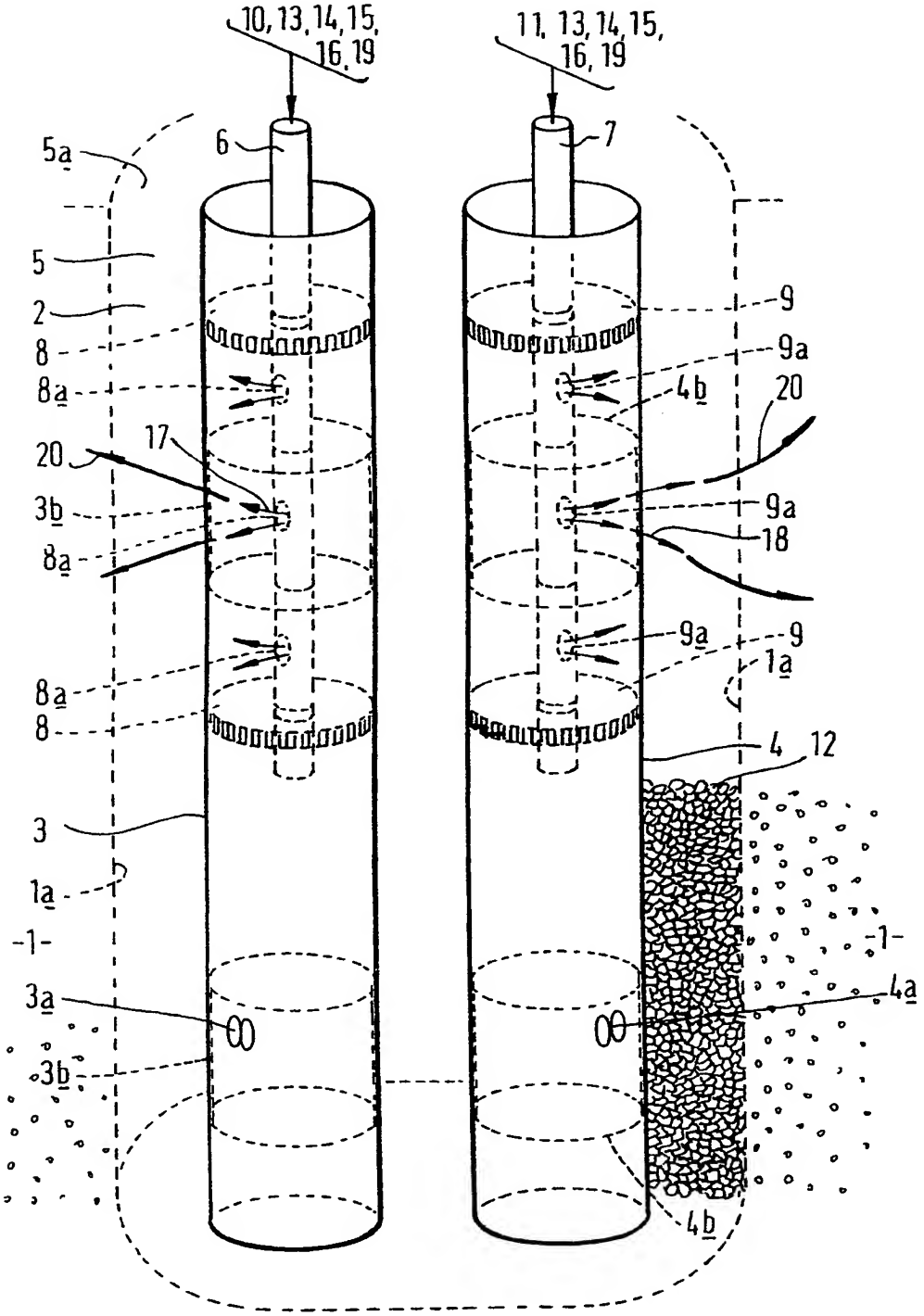

SPECIFICATION

Soil improvement method

This invention relates to a process for the improvement of the load bearing properties of soils containing loose stones by injecting a rapidly hardening injection substance into the soil. The process of the invention is particularly applicable to water-impermeable or slightly water-permeable soils ie, cohesive soils.

Injection processes for improving soils have so far only been successfully used in water-permeable soils containing loose stones. The effect of the injection substances in such soils consists in their acting as a hardening pore filling whereas in water-impermeable or only slightly water-permeable soils the known injection processes are unsatisfactory because even low-viscosity injection liquids are unable to penetrate the soil to be treated to a sufficient extent to produce a homogeneous foundation soil capable of bearing loads.

It is an object of the invention to provide an improved process for the treatment of soils containing loose stones and, in accordance with the invention, the process comprises forming a bore hole in the soil to be treated; inserting a pair of tubular members within the bore hole; filling the bore hole with a solidified foam sealing material; inserting an injection pipe into each tubular member, each said pipe being provided with a pair of axially spaced sealing discs defining a sealable cavity between each pipe and its associated tubular member, each pipe having a liquid outlet therein opening into said cavity and being slidable within the tubular member to bring the said cavity into selective alignment with one or more valved outlets spaced axially of each tubular member; discharging injection liquids out of the said outlets in the pipes into the said cavities and thence out of the valved outlets in the tubular members into the said foam sealing material in the bore hole, the liquids discharged from each tubular member being of differing compositions and reacting rapidly to form a solidified mass which penetrates the foam sealing material to enter the soil surrounding the bore hole.

The injection liquids are generally grout which include a low water content expanding agent, such as aluminium powder, together with a filler additive.

A further liquid may be discharged out of the said outlets in the tubular members, said further liquid comprising a hardening activating agent such as water glass together with a foaming agent. The water glass may be additionally mixed with aluminium powder or a polyurethane component.

Other features of the invention will become apparent from the following description given herein solely by way of example with reference to the accompanying drawing which shows a longitudinal section of the twin tubular members/injection pipes of the invention located within a bore hole.

Referring to the drawing, a bore hole 2 is formed in the soil 1 which is to be treated and a pair of vertically extending horizontally spaced apart tubular members 3 and 4 are placed in the bore hole 2. Each tubular member 3, 4 is provided with a respective outlet 3a, 4a together with a respective flexible covering sleeve 3b, 4b which causes the outlets 3a and 4a to function as non-return valves.

The remaining bore hole volume 5 surrounding the tubular members 3 and 4 is first of all filled with a solidified foam sealing material 5a. Such sealing material may either be filled directly in to the bore hole or may be injected therein through the interiors of the tubular members 3 and 4 to flow into the bore hole through the valved outlets 3a and 4a.

A respective injection pipe 6, 7 is then slidably inserted into an associated tubular member 3, 4. Each pipe 6 and 7 is provided with a so called "double packer" which comprises a respective pair of axially spaced apart sealing discs 8, 9 defining a sealable cavity between each pipe and its associated tubular member. Each pipe 6 and 7 is provided with a liquid outlet 8a, 9a opening into the cavity defined between the two sealing discs. Thus by sliding each pipe 6, 7 in its associated tubular member 3, 4, each cavity may be brought into selective alignment with the valved outlets 3a and 4a in the tubular members. Injection liquids 10, 11 suitably pressurised by injection pumps may thus be discharged out of the pipes 6 and 7 through their respective outlets 8a and 9a into the cavities and then out of the valved outlets 3a and 4a at selective vertical levels within the bore hole; the flexible sleeves 3b and 4b covering the outlets 3a and 4a preventing the back flow of injection liquid from the bore hole into the tubular members.

The injection liquids 10 and 11 discharged into the bore hole out of the tubular members 3 and 4 are of differing compositions and are thoroughly mixed upon discharge from the valved outlets 3a and 4a to form a rapidly solidified mass which penetrates through the foam sealing material 5a to enter the soil surrounding the bore hole. In other words, the solidified mass 12 rapidly breaks through the sealing agent 5a, to break open the existing soil wall 1a, at the specific vertical level at which the injection liquids are discharged out of the outlets 3a and 4a in the tubular members. As a result of this process, the existing soil is displaced, compressed and then re-compressed following the subsequent swelling of the injected liquid.

The injection liquids 10, 11 are grout and are mixed and injected with a further liquid acting as a hardening activating agent 16. The swelling process referred to above is caused by adding an expanding agent 13, for example aluminium powder 14, which, due to the presence of filler additives 15, has a low water content. The hardening activating agent consists of water glass 17 and a masked foam forming agent 18 which is additionally mixed either with aluminium powder 14 or a polyurethane component 19.

After the process of hardening the injected liquids has been completed, a firm, foam-like and loadable consolidation member 20 with fine pores is produced in the soil 1 with such consolidation member having a pre-determined height and penetration depth and with its pore volume receiving excess water from the soil.

CLAIMS

1. A process for the improvement of the load-bearing properties of soil containing loose stones comprising forming a bore hole in the soil to be

treated; inserting a pair of tubular members within the bore hole; filling the bore hole with a solidified foam sealing material; inserting an injection pipe into each tubular member, each said pipe being provided with a pair of axially spaced sealing discs defining a sealable cavity between each pipe and its associated tubular member, each pipe having a liquid outlet therein opening into said cavity and being slidable within the tubular member to bring the said cavity into selective alignment with one or more valved outlets spaced axially of each tubular member; discharging injection liquids out of the said outlets in the pipes into the said cavities and thence out of the valved outlets in the tubular members into the said foam sealing material in the bore hole, the liquids discharged from each tubular member being of differing compositions and reacting rapidly to form a solidified mass which penetrates the foam sealing material to enter the soil surrounding the bore hole.

2. A process as claimed in claim 1 wherein the injection liquids comprise a grout.

3. A process as claimed in either one of claims one of claims 1 or 2 wherein the injection liquids include a low water content expanding agent.

4. A process as claimed in claim 3 wherein the injection liquids include a filler additive and the expanding agent comprises aluminium powder.

5. A process as claimed in any one of the preceeding claims wherein a further liquid is discharged out of the said valved outlets in the tubular members, said further liquid comprising a hardening activating agent.

6. A process as claimed in claim 5 wherein the hardening activating agent comprises water glass and a foaming agent.

7. A process as claimed in claim 6 wherein the water glass is additionally mixed with aluminium powder.

8. A process as claimed in claim 6 wherein the water glass is additionally mixed with a polyurethane component.

9. A process for the improvement of the load-bearing properties of soil containing loose stones substantially as hereinbefore described with reference to the drawings.

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